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U.S. PATENT APPLICATION

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Invention: ADJUSTING METHOD FOR CENTERING EARTH ELECTRODE AT CENTER ELECTRODE OF SPARK GAP OF SPARK PLUG

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SPECIFICATION

ADJUSTING METHOD FOR CENTERING EARTH ELECTRODE AT CENTER ELECTRODE OF SPARK GAP OF SPARK PLUG

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an adjusting method for centering an earth electrode at an axis of a center electrode of a spark gap of a spark plug for an internal combustion engine mounted on a automotive vehicle.

2. Description of the Related Art

In conventional spark plugs, a columnar center electrode is fixed and electrically isolated in the spark plug housing, while one end of the earth electrode is welded to the hausing and the other end of the earth electrode is bent perpendicular to the tip surface of the center electrode, thereby forming a spark gap.

The spark gap length is adjusted within a prescribed tolerance and further a positional difference (measured along a direction perpendicular to the axis of the center electrode) between the axis of the center electrode and the center of the end surface of the earth electrode is also adjusted within other prescribed tolerance. It is ideal that the off-axis positional difference is zero.

Although, for example, JP2000-329529A discloses a method for observing the spark gap, wherein an edge

image of the center electrode and earth electrode is obtained by an oblique illumination surrounding them and the image is processed, there is not yet in the field of the image processing any established method for measuring the above-mentioned off-axis positional difference between the center electrode and earth electrode. Thus, the off-axis positional difference could not be efficiently adjusted.

SUMMARY OF THE INVENTION

An object of the present invention is to efficiently adjust a positional difference (measured along a direction perpendicular to the axis of the center electrode) between the center electrode axis and the center of the earth electrode.

The present invention is directed to an adjusting method for centering an earth electrode at a center electrode of a spark gap of a spark plug.

In the adjusting method of the present invention, an illuminating step is executed for illuminating said spark plug from a front of a surface of an end tip of said earth electrode.

Next, an image picking-up step follows for picking up a reflected image of said spark gap.

Next, a calculating step follows for calculating a center of the tip surface of said earth electrode and axis of said center electrode on the basis of said reflected image.

Next, a moving step follows for moving said earth electrode toward said axis.

Next, a measuring step follows for measuring a positional difference between said axis of said center electrode and center of said earth electrode along a direction perpendicular to said axis of said center electrode.

According to the present invention, the reflection illumination employed in the present invention enables to precisely measure and efficiently adjust the above-mentioned off-axis positional difference, although it was difficult to measure the above-mentioned off-axis positional difference by the transmitting illumination due to a leg portion of the earth electrode which stands up from the spark plug hausing and hides the spark gap, the reflection illumination as employed in the present invention enables to precisely measure and efficiently adjust the above-mentioned off-axis positional difference.

Further, according to the present invention, the center position of the earth electrode is defined by an area center (area centroid) of said reflected image of said earth electrode, whereby the above-mentioned off-axis positional difference is more precisely obtained by the image processing process, although the conventional image processing by the edge processing method could not give a precise center position of the earth electrode, due to fluctuation of the cross sectional shape of the earth electrode.

Further, according to the present invention, the earth

electrode is moved toward the center electrode axis, taking into consideration a spring-back which is caused after completing the adjustment step, thereby more precisely adjusting the above-mentioned off-axis positional difference.

BRIEF EXPLANATION OF THE DRAWINGS

FIG. 1 is a block diagram of an apparatus for adjusting a spark gap, wherein a reflected image of the spark gap seen from a front of a tip surface of the earth electrode is inputted and processed.

FIG. 2 is a conceptual elevational view of an adjustment unit included in the apparatus as shown in FIG. 1.

FIG. 3 is an enlarged partial elevational view of the spark plug around the center electrode and earth electrode.

FIG. 4 is a side view of the spark plug as seen from direction "A" in FIG. 3.

FIG. 5 is an illustration for explaining a principle for adjusting the off-axis positional difference (measured along a direction perpendicular to the center electrode axis) between the center electrode axis and center of the earth electrode.

FIG. 6 is a flow chart for adjusting the off-axis position difference.

PREFERRED EMBODIMENT OF THE INVENTION

Preferred embodiment is explained, referring to the drawings.

A spark plug 1 as shown in FIG. 1 has a cyrindrical hausing 10 into which a cylindrical ceramics insulator 11 is inserted and fixed therein. Further, a cylindrical center electrode 12 is inserted into a hole around the axis of the insulator 11 and fixed therein. Further, an earth electrode 13 made of Ni alloy is welded to the hausing 10. The earth electrode 13 as shown in FIG. 3 comprises: a leg 13a extending parallel to the axis "X" of the center electrode 12; and an opposite portion extending perpendicular to the axis "X". A part of the leg 13a is welded to the hausing 10. The opposite portion is disposed opposite to the tip 12a of the center electrode 12. A spark gap is formed between the tip 12a and opposite portion 13b.

An image pick-up unit 2 (comprising a CCD camera 21 and illumination device 22 as shown in FIG. 1) picks up an image of the electrodes 12 and 13. The picked-up image is sent to an image processing unit 3. The tip 12a and tip surface 13c of other end of the earth electrode 13 are illuminated from the front of the tip surface 13c.

The image processing unit 3 calculates the positional difference "C" as shown in FIG. 5 between the axis "X" of the center electrode 12 and center "Y" of the electrode 13.

An adjustment unit 5 connected with the image processing unit 3 causes the positional difference "C" to decrease by driving a motor through a motor controller 4.

The positional difference "C" as shown in FIG. 5 is defined by a distance between "X" and "Y" along a direction perpendicular to "X", when seen from the front of the tip surface 13c.

The positional difference between the two electrodes is adjusted by the motor control unit 4 which controls a motor 51 as shown in FIG. 2 of which rotation is transferred through a first gear 52 to a second gear 53 of which axis 53a is provided with a male screw 53b. The axis 53a is inserted into a holder 54.

The holder 54 is provided with a not-shown female screw, thereby moving the holder 54 along the right and left direction in accordance with the rotation direction of the motor 51. Further, the holder 54 is provided with two jigs 55 (disposed opposite at a prescribed distance) for alternately pushing the earth electrode 13.

Further, the adjustment unit 5 is provided with two chucks 56 for chucking the hausing 10 of the spark plug 1 from both right and left sides. The chucks 56 are moved back and forth by hydraulic cylinder apparatus 57.

Next, the positional difference adjustment process is explained, referring to FIG. 6.

First, at S10, the image processing unit 3 inputs from the CCD camera 21 a picked-up image of the tip 13c of the earth electrode 13.

Then, at S11, the image processing unit 3 calculates an area center (centroid) of the tip surface 13c which is deemed to be the center of the area of the tip surface 13c.

In the picked-up image as shown in FIG. 5, a polygonal outline of the tip surface 13c of which center is "Ye" decided by the edge processing method is expressed by solid lines, while its actual outline of which center is "Yr" is shown by a dotted line (one-dot chain line). Here, "Ye" is an equidistant point from the polygon vertexes. "Ye" actually differs from "Yr", depending upon the tip shape fluctuation. However, it was confirmed by the inventor that the difference between "Ye" and "Yr" becomes small if "Ye" is defined by the area centroid of the tip surface 13c.

Then, at S12, an image of the tip 12a of the center electrode 12 is inputted from the CCD camera 21 into the image processing unit 3.

Then, at S13, the image processing unit 3 calculates an area centroid of the tip 12a which is deemed to be the axis "X" of the center electrode 12.

Then, at S14, the difference "C" between "Y" ("Ye") and "X" is calculated.

Then, at S15, the earth electrode 13 is moved toward the axis of the center electrode 12 in order to decrease the difference "C".

Here, S15 is concretely explained, referring to FIG. 5.

First, a displacement "D" (= B + C + SB) of the jig 55 is calculated, where "B" is a distance (before moving the earth electrode 13) between the earth electrode and jig 55, "C" is a positional difference obtained at S14 and "SB" is a prescribed spring-back after the jig's returning back to its original position after having moved the earth electrode 13.

In FIG. 5, the earth electrode 13 which was moved by "D" is shown by a dotted line (one dot chain line), while the earth electrode 13 which was moved back by the prescribed spring-back "SB" is shown by a two-dot chain line. Further, the above-mentioned two positions of the earth electrode 13 are shifted upward, respectively, for clearly illustrating the two positions.

After calculating the displacement "D", the jig 55 is moved by "D" by the motor 51 controlled by the motor controller 4, thereby moving the jig 55 to the position shown by the dotted line. Thereafter, the jig 55 is moved back to an original position by reversely rotating the motor 51. However, the earth electrode 13 is moved back to the position shown by the two-dot chain line as shown in FIG. 5.

Then, at S16, the positional difference "C" after completing the position adjustment at S15 is measured again. If "C" is determined to be within a prescribed tolerance, then the adjustment process is completed. On the other hand, if "C" is determined not to be within a prescribed tolerance, then, S10 to S15 are repeated.

In addition to the above-explained adjustment process steps, a chucking step for chucking the spark plug 1 may be executed, before illuminating the spark gap or before picking up the spark gap image.